GEOPHYSICAL CHARACTERISTICS OF THE ATLANTIC OCEAN

By

Edwin R. Fritz

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The Ohio state University

Thesis Advisor

Department of Geology and Mineralogy

Introduction

Over the past couple of decades, an abundance of detailed geophysical data have been collected and analyzed in both the North and South Atlantic Oceans. These data have been primarily derived from marine seismic, gravity, and magnetic surveys, from marine heat flow studies and from a study of the seafloor's paleomagnetic anomalies. Considered separately, each of these geophysical techniqies can yield precise and detailed information. However, considered collectively, they may lead to the recognition of much larger scale relationships as to the origin and development of the oceanic crust and possibly to the evolution of the Atlantic Basin.

Recently, satellite magnetic and gravity data have become available for study and analysis. To facilitate the use of these data for investigations of the Atlantic Basin, this paper has compiled a number of key geological and geophysical data sets. These are described on plates 1 through 6 and consist of the following: Plate 1 is a regional depiction of the Atlantic's physiographic regions and their tectonic features. This plate is useful in noting the possible relationships between the sea floor's surface features and the location of gravity and magnetic anomalies. Furthermore, Plate 1 is especially useful in noting the correlations with Plate 2, which depicts the Atlantic's present day hot spots and their tracks since the opening of the Atlantic, as described by Morgan (1983). Surface features such as volcanic islands, submarine rises, and seamounts are all direct evidence of the existence of these hot spots. The hot spot tracks trace the regions of high heat flow in the Atlantic, which again may relate to the location of certain gravity and magnetic anomalies.

Plate 3 describes the First Radial Derivative Free Air Gravity Anomalies which were derived principally from shipborne and satellite altimeter data (Rapp,). These gravity anomalies may be related to concentrations and thinnings of the oceanic lithosphere and are most apparent around tectonic features such as the Puerto Rico Trench. Plate 4 describes the magnetic anomalies of the Atlantic as collected by the magnetic satellite, MAGSAT. These data have been differentially reduced to the pole so that the anomalies directly map out the lateral geometric and property variations of their lithospheric sources.

Plate 5 identifies the presently known geomagnetic anomalies of the Atlantic (Owens, 1983). These geomagnetic anomalies are primarily useful in determining the crustal ages of the Atlantic Basin. Consequently, Plate 5 was used extensively in constructing Plate 6, which gives an approximate location for regions of equal crustal age in the Atlantic Basin. This plate is useful in determining the ages of certain seafloor features of anomalies.

This paper briefly discusses each of the geophysical data sets as described in Plates 1 through 6.

Physiographic and Tectonic Features

Plate 1 describes the major regional physiographic and tectonic features of the Atlantic. The data for this chart was derived primarily from the "World Ocean Floor," a chart published by the National Geographic Society (1981). Further detail was gained by studying G.S.A. chart MC-35 (1981) titled "North Atlantic Ocean: Bathymetry and Plate Tectonic Evolution." Note that the physiographic boundaries depicted in Plate 6 do not correlate to any particular depth or distance. They simply reflect the apparent extent of the major physiographic features. Accordingly, a good deal of subjectiveness was involved in assigning boundaries, particularly in regions where one feature simply grades into the next. Therefore, the accuracy of this chart is only appropriate for regional comparisons and should not be used for work that requires greater detail.

The most obvious feature of the Atlantic Ocean is its near bilateral symmetry around the Mid-Atlantic Ridge system. Although interrupted by the equatorial fracture zone, which offsets the ridge axis eastward by more than 30° of longitude, this bilateral symmetry is maintained throughout the Atlantic. Generally speaking, the Atlantic may then be divided up into three physiographic provinces: 1) The Continental Margin, 2) The Ocean-Basin Floor, and 3) the Mid-Atlantic Ridge.

The continental margins in the Atlantic are tectonically passive and are depicted as the first boundary away from the continents (Plate 6). They consist of a continental shelf, a continental slope, and a continental rise, each of which is best defined by their general gradients rather than by their depths, which may be quite variable. The shelf has a barely perceptible gradient of 1:1000, the slope has a much steeper gradient of 1:40 or greater, and the continental rise, which is located at the base of the continental slope, has a gradient of approximately 1:300.

The ocean-basin floor province emerges gradually from the continental rise, and is characterized by wide regions with little or no topography. In fact, the abyssal plains of the ocean-basin are the flattest surfaces found on earth. However, the ocean-basin floor often has some local relief present in the form of low abyssal hills and the presence of seamount chains and submarine volcanoes.

The mid-Atlantic ridge province serves as the line of symmetry for the Atlantic Ocean. It is typified by rugged topography which is associated with the presence of numerous submarine volcanoes and many prominent east-west trending fracture zones. The Mid-Atlantic Ridge itself consists of a rift valley which lies approximately 1000 M below its adjacent rift mountains. This valley is around 1000 M wide and is covered by young basaltic lava flows. The adjacent rift mountains have depths of approximately 1700 M. This province may be from 4° to 15° of longitude wide, with the narrowest regions being near Iceland and the 4°N fracture zone, and the widest regions being roughly centered in the middle of both the North and South Atlantic. Depths at the margins of this province may be up to 4 Km.

The Atlantic Ocean's deepest depths may be found in the Atlantic's only region of subductive activity, the Puerto Rico Trench. This subduction zone runs roughly east-west just north of Puerto Rico and reaches depths of 27,500 ft. Its presence is directly related to the evolution of the Caribbean Sea.

An interesting feature of the Atlantic is that the depth of its ocean floor has been shown to be relatively constant for a given age. Sclater et al (1981) has shown that for ocean floor younger than 70 Ma., the mean depth increases linearly with the square root of its age (Figure 2). This behavior can best be explained as simply a result of the cooling of the basalt which was intruded near the ridge axis. With increasing age, the depths exponentially approach an equilibrium value of roughly 6400 M, which is related to the flows maximum level of compaction due to cooling.

Hot Spots and Their Tracks

Hot spots, or regions of high thermal heat flow, have a high correlation with the physiography of the Atlantic seafloor. These hot spots usually have some type of surface expression, commonly noted as a volcanic island, a submarine volcano, a submarine ridge, or a seamount. Of course with the advent of the theories of sea-floor spreading and continental drift, and with the realization that hot spots remain relatively fixed in their location while the crust above them move, one would expect that hot spots would leave a track of surface features upon the oceanic crust. These features may be observable as island chains, seamount chains, aseismic ridges, or perhaps as oceanic rises.

Hot spots and their tracks have proven to be especially useful as a reference frame to determine plate motions for the opening of the Atlantic. Morgan (1983) has plotted the prominent hot spots and their tracks in the North and South Atlantic, primarily by fitting their trends with the seafloor topographic features (Plate 2). With respect to Plate 2, the darkened circles represent present day hot spot locations, the solid lines represent their tracks, and the dashed lines connect the end of a track on one plate with its continuation on another. Because this chart was constructed by moving the crustal plates over perfectly fixed hot spots, which may not always have been the case as various hot spots have been shown to undergo some amount of wander (Morgan, 1983), the absolute accuracy of this reconstruction is somewhat suspect. However, on a regional scale, these errors are negligible and so this reconstruction is still quite valid.

The following tracks fit Morgan's reconstruction very well. Tristan closely follows the center of the Walvis Ridge from 110 M.A. to the present and various age determinations along the ridge give strong support for these predicted ages. The Great Meteor hot spot in the North Atlantic closely follows the New England Seamount Chain, the Corner Rise, and the Cruiser-Hyeres-Great Meteor line of seamounts on the African side of the Atlantic. Again, this track correlates well with known ages of the topographic features present. Morgan primarily used these two tracks as the constraints for his plate motions from earliest Cretaceous until the present.

To further constrain the plate motion during the Tertiary, Morgan used three other tracks. Although the Trindade track has no measured progression of ages, this distinct line of seamounts constrains the motion of South America to be that of primarily east-west for some indefinite period of time. The second track is noted by Morgan as the following, "The Bermuda Swell, the island of Bermuda, the Cape Fear Arch, and the highest uplift of the old Appalachian Mountains in North Carolina and Tennessee mark the motion of North America over a hot spot, and with some age control." The last track places Skaergard over the present position of Iceland which acts as a further constraint on Tertiary motion.

Morgan further noted that "...two tracks closely follow lines which become sites of continental breakup." The first was inland at the northern extent of South America, and probably was related to the split between Mexico and Central America. The second involves the Madgira track which is parallel to the north side of the Grand Banks, the north coast of Spain; and to the southern end of Rockall Bank, Irish continental margin, and the Brittany continental margin. Further, the timing of this track is such that it predates the opening of the North Atlantic and the Bay of Biscay.

Geomagnetic Anomalies

The relatively recent discovery of lineated magnetic anomalies by Mason and Raff (1961) led in 1963 to Vine and Matthews intial hypothesis that there was a connection between the growth of oceanic crust from spreading centers and the generation of symmetrical geomagnetic lineations parallel to their active ocean ridges. This theory quickly gained strong support and has since initiated the appearance of an abundance of literature on marine geomagnetic anomalies.

Accordingly, a magnetic polarity time scale was devised which identifies each anomaly with a certain age (Table 1). This time scale then allows worldwide correlations between the various ocean basins and their geomagnetic anomalies. With respect to Table 1, anomalies 1 through 34 are normally orientated, although they may include minor reversals. Anomalies MO through M26 are reversed unless otherwise indicated.

The appearance of geomagnetic anomalies in the Atlantic follows a regular and predictable pattern. Owens (1983) has compiled these anomalies for the Atlantic as depicted in Plate 5 - Atlantic Paleomagnetic Anomalies. For the North Atlantic, the anomalies may be divided into four distinct zones which are best and most clearly seen in the North Atlantic's south-western region, near the Kane Fracture Zone (Vacquier, 1972).

Table 1. *Magnetic polarity time scale for the Mesozoic and Cenozoic*

Anomaly no.	Estimated age Ma B.P.*	System and stage	
1	0.0–0.7	QUATERNARY	Pleistocene
2	1.6–1.8		
2A	2.4–3.3	TERTIARY	Pliocene
3	3.7–4.6	(Neogene)	
3A	5.1–5.6		Miocene
4	6.4–7.0		
5	8.3–9.7		
5A	10.9–11.5		
5B	14.3–14.7		
5C	15.7–16.5		
5D	17.1–17.7		
5E	18.1–18.7		
6	19.0–20.0		
6A	20.5–21.4		
6B	22.2–22.6		
6C	23.0–23.9	(Palaeogene)	Oligocene
7	25.2–25.7		
7A	26.1–26.3		
8	26.6–27.5		
9	28.0–29.0		
10	29.6–30.2		
11	31.1–32.0		
12	32.4–32.8		
13	35.3–35.9		
15	37.3–37.7		
16	38.1–39.3		Eocene
17	39.6–41.2		
18	41.4–42.9		
19	43.8–44.2		
20	44.9–46.4		
21	49.0–50.7		
22	52.3–53.0		
23	54.3–55.1		
24	55.6–56.6		Palaeocene
25	58.7–59.2		
26	60.0–60.4		
27	62.3–62.7		
28	63.3–64.0		
29	64.3–64.9		
30	65.4–66.8	CRETACEOUS	Maastrichtian
31	66.8–67.6	(upper)	
32	69.2–71.0		
33	71.6–76.5		Campanian (part)
34	79.6–87.5		Santonian
unnumbered (reversed)†	87.5–88.0		Turonian
35 & 36†	88.0–103.8		Turonian–Albian
unnumbered (reversed)†	103.8–104.0	(lower)	Albian
M0‡	110.9–111.6		Aptian
M1	114.3–114.7		Barremian
M2 (normal)	114.7–115.4		
M3	115.4–117.5		
M4 (normal)	117.5–118.5		
M5	118.5–119.0		Hauterivian
M6	119.2–119.3		
M7	119.5–119.9		
M8	120.2–120.4		
M9	120.7–121.2		
M10	121.5–121.9		
M10N	122.9–123.2		
M11	124.5–124.8		Valanginian
M12	126.0–126.7		
M13	127.7–128.1		
M14	128.3–129.2		
M15	129.8–130.3		
M16	132.1–132.8		Berriasian
M17	133.3–134.9		
M18	135.5–136.0	JURASSIC	Tithonian
M19	137.6–137.9	(upper)	
M20	139.0–139.9		Kimmeridgian
M21	141.2–141.7		
M22	143.7–144.6		
M23 (normal)	145.6–145.7		Oxfordian
M24	147.2–147.4		
M25	148.7–149.0		
	150.0§		Callovian

* Estimated interval in millions of years before present (B.P.) to the nearest 100000 years.

† These include the normal and reversed anomalies mapped in the southern Pacific in the region of New Zealand, and those labelled A–C in the south-western part of the Wharton Basin of the Indian Ocean.

‡ The age calibration of the M series of magnetic anomalies given by Larson & Hilde (1975) has been revised by Vogt & Einwich (1979). However, the ammonite evidence available agrees more closely with the Stage correlations of Larson & Hilde rather than those of Vogt & Einwich. The arguments used by Vogt & Einwich in their revision of Larson & Hilde, illustrate the amount of uncertainty that there is in the dating of magnetic anomalies at fine detail level. This variation does not affect, fundamentally, the reconstructions given in this atlas.

§ Long periods of normal polarity with little reversal activity occur in the Cretaceous, between the Aptian and the Coniacian, and in the lower and middle Jurassic. Crust generated during these intervals is described as being magnetically 'quiet'. Low-amplitude reversals have been detected, however. One example, with a revision of dates, extends the M sequence to M29 (*ca* 157 Ma) within the Callovian (Cande, Larson & La Brecque 1978).

Compiled essentially from La Brecque, Kent & Cande (1977) and, with modifications, from Vogt & Einwich (1979). Anomalies 1–34 are normally oriented although they include minor reversals. Anomalies M0–M26 are reversed unless indicated otherwise.

1. Along the 28th parallel, the standard chronology of geomagnetic reversals may be followed westward from the ridge at 42° W until reaching anomaly 34 at about 58° W.
2. From 58°W to 67°W lies a region of confused anomalies which cannot be identified from one profile to the next. This region is often referred to as the "Cretaceous Quiet Zone."
3. Between 67°W and 72°W an orderly set of lineated anomalies called the Keathley Sequence extends from about 23°N to 34°N. This zone includes most of the M series anomalies.
4. West of anomaly M20 lies the "Quiet Zone," which derives its name for the abrupt transition from a "rough" to a "smooth" magnetic field.

Although these zones may not always be immediately apparent in different regions of the North Atlantic, they are indeed present, and they find their symmetrical mirror image on the eastern side or margin.

Geomagnetic anomalies are primarily beneficial in dating the age of the oceanic crust, as discussed with the geomagnetic time scale. Between geomagnetic anomaly age determinations and the study of deep sea core samples, a regional scale map can be constructed which depicts the ages of the oceanic crust, as seen in Plate 6. This chart was derived from work completed by Sclater and Parsons (1981) and from G.S.A. Chart

MC-35, which is of the North Atlantic.

With respect to Plate 6, data for the North Atlantic was primarily derived from Chart MC-35. The authors compiled their data as follows:

> The age chart was constructed by interpolating and extrapolating the magnetic lineations ...(and from) numerous other literature sources (e.g. Volt and Kinwich, 1979, Schouten and Klitgord, 1977, and Srivastava, 1978, for the western Atlantic). Considerable license was used in judging offsets of isochrons across fracture zones.

The authors left oceanic areas of highly uncertain age uncolored.

The data for the South Atlantic and the equatorial region were derived in much the same manner. From the geomagnetic lineations (Owens, 1983), and from Sclater and Parson's age depictions, I constructed a rough and approximate age map for the South Atlantic. On a regional scale, the accuracy should be acceptable, however there does lie some question to the degree of isochron offset, primarily in the region from 10^{o}S to 20^{o}S.

Magnetic Anomalies

Satellite magnetic observations are a relative newcomer to the field of geophysical investigation. The most recent data available have been collected by the polar orbiting magnetic satellite, MAGSAT, which flew from November, 1979 through June, 1980. These data have been differentially reduced to the pole in order that the anomalies directly map out the lateral geometric property variations of their lithospheric sources (Von Frese, 1984), as depicted in Plate 4.

With respect to Plate 4, the most striking feature immediately apparent are the similarities between the trend of the magnetic anomalies, particularly in the South Atlantic, with the trend of the hot spot tracks, as seen in Plate 2. Both the magnetic anomalies and the hot spot tracks exhibit to varying degrees a north-easterly trend. However, there seems to be no consistent magnetic anomaly value or sign associated with these tracks. Von Frese, et al have noted though that "... it seems plausible that the hot spots may indeed leave a magnetic signature imprint by virtue of their related thermal aureoles and magmatic activity. The origin of these anomalies and why they are prevalently limited to the South Atlantic is not understood."

GRAVITY ANOMALIES

Plate 3 describes the first Radial Derivative Free Air Gravity Anomalies which were derived principally from shipborne and satellite altimeter date (Rapp.). Relationships which can be drawn from this data are limited, however there does appear to be a correlation between gravity anomalies and certain tectonic or physiographic features. The most prominent example is that of the Puerto Rico Trench and the negative gravity anomalies associated with it. Note, however, that the anomaly does not coincide directly with the location of the trench, as it lies just to the North.

Other examples include the positive gravity anomalies associated with the Bermuda Rise and the Walvis Ridge. Again, the anomalies seem to be offset from the physiographic feature,but no perceptive trend in this behavior can be recognized.

The correlation between the geophysical characteristics of the Atlantic Ocean seems to be of a quite limited nature. However, certain relationships do exist. First, the pressure of hot spots and their tropas. Second, the trends of thesehotspot tracks in the South Atlantic bear a remarkable resemblance to the trends of the

Plate 1. SEAFLOOR TOPOGRAPHY and PHYSIOGRAPHY

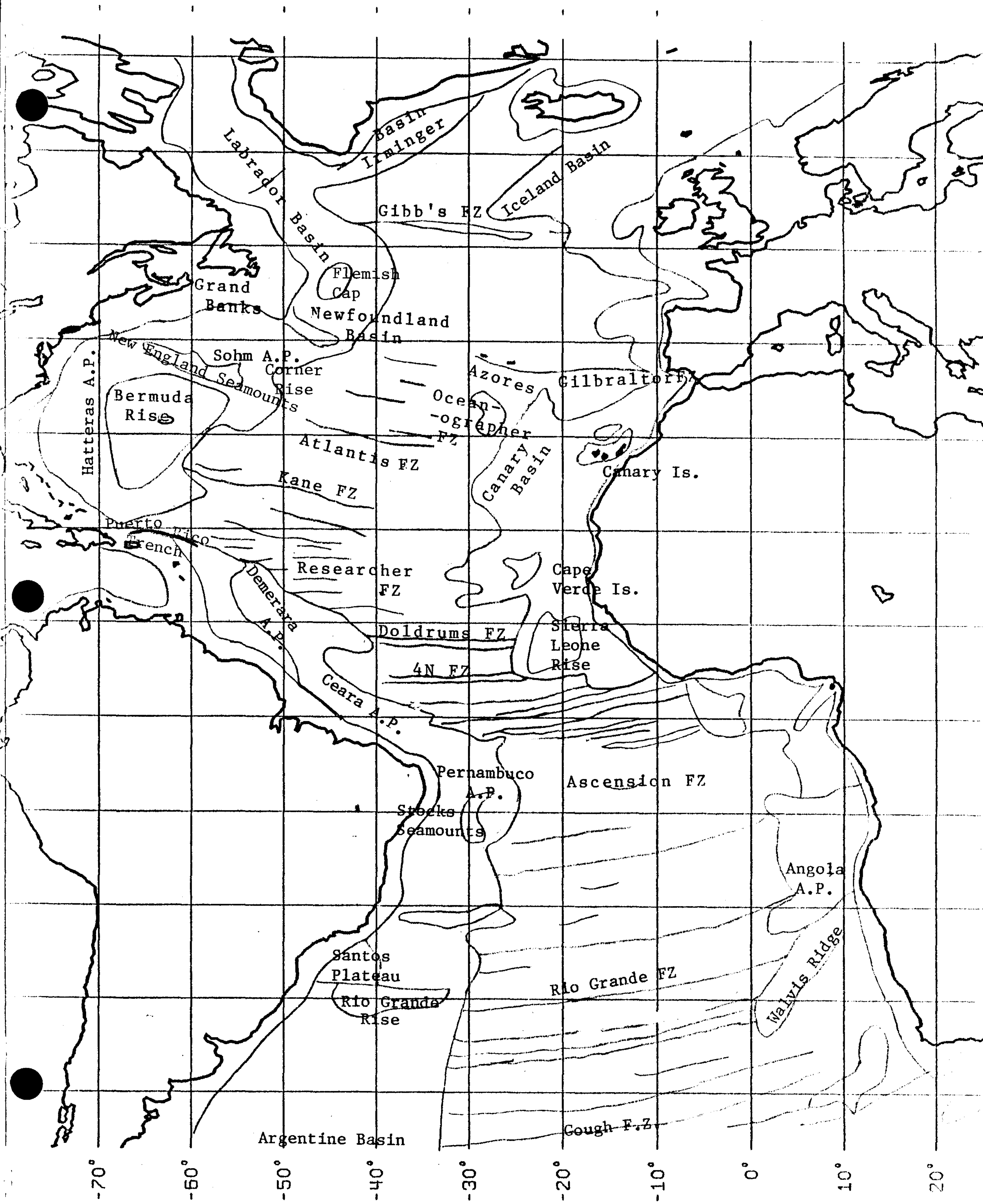


Plate 2. HOTSPOTS and their TRACKS (after Morgan, 1983)

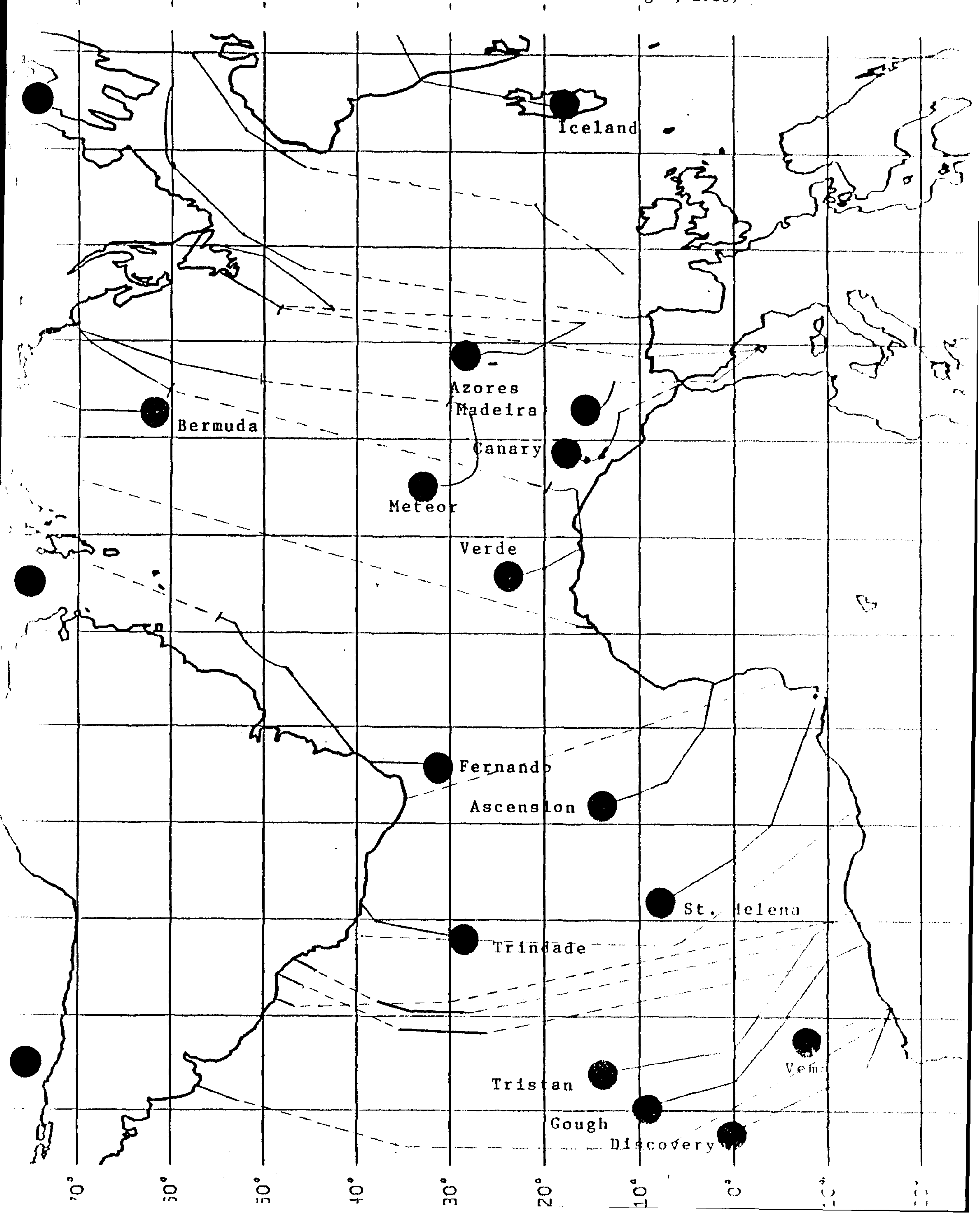


Plate 3. FIRST RADIAL DERIVATIVE FREE-AIR GRAVITY ANOMALIES (after

Z= 400 km 90 x 90 SH-Expansion

AR=(66,-51)x10^{-3}Mgal/km CI=10x10^{-3}Mgal/km AM=0.345x10^{-3}Mgal/km

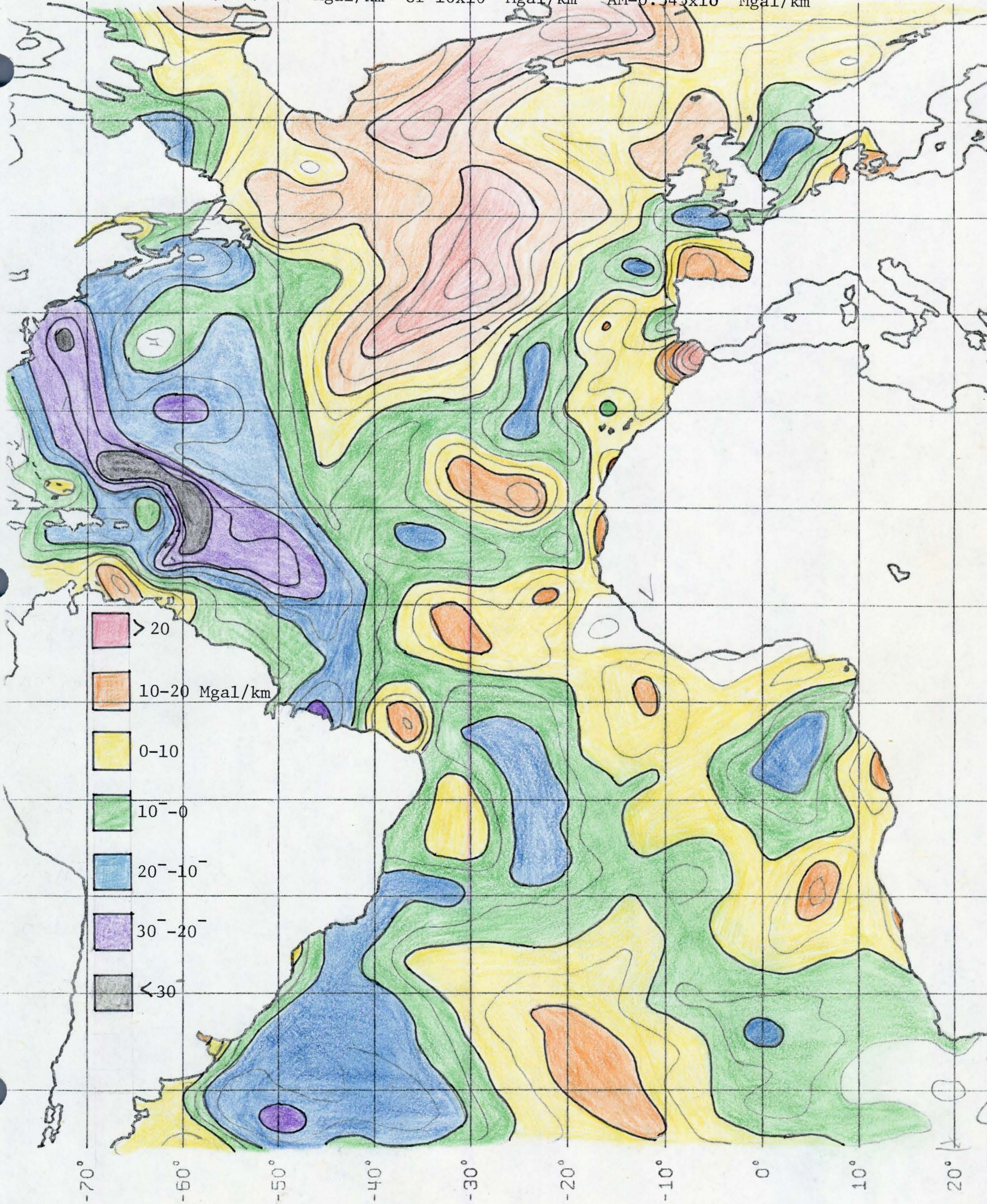


Plate 4. RADIALLY POLARIZED (2°) MAGSAT MAGNETIC ANOMALIES

Z= 400 km AMP= 60000 nT

AR= (32.8,-25.1) nT CI= 4 nT AM= -0.8 nT

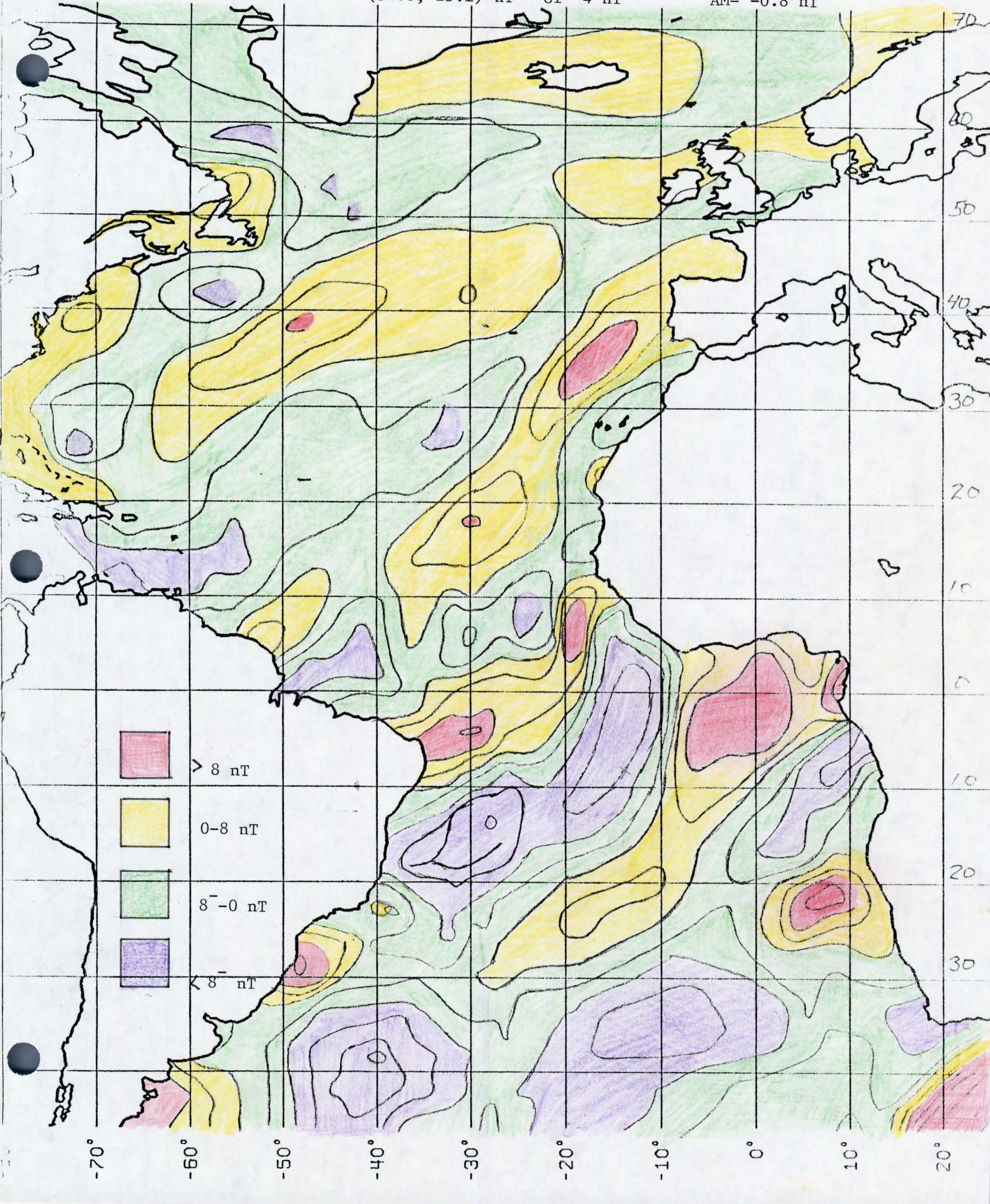


Plate 5. GEOMAGNETIC ANOMALIES of the ATLANTIC (after Owens, 1983)

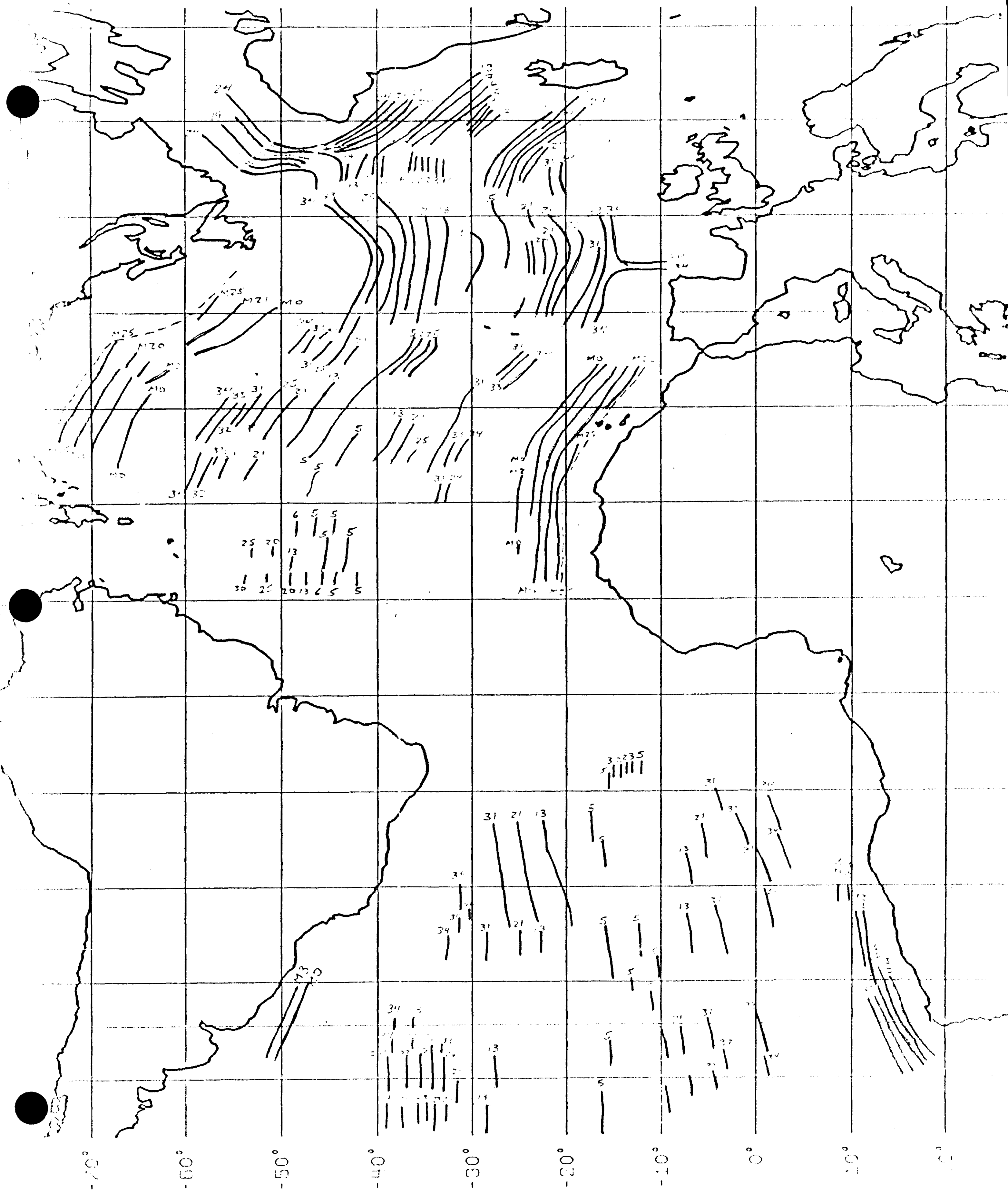
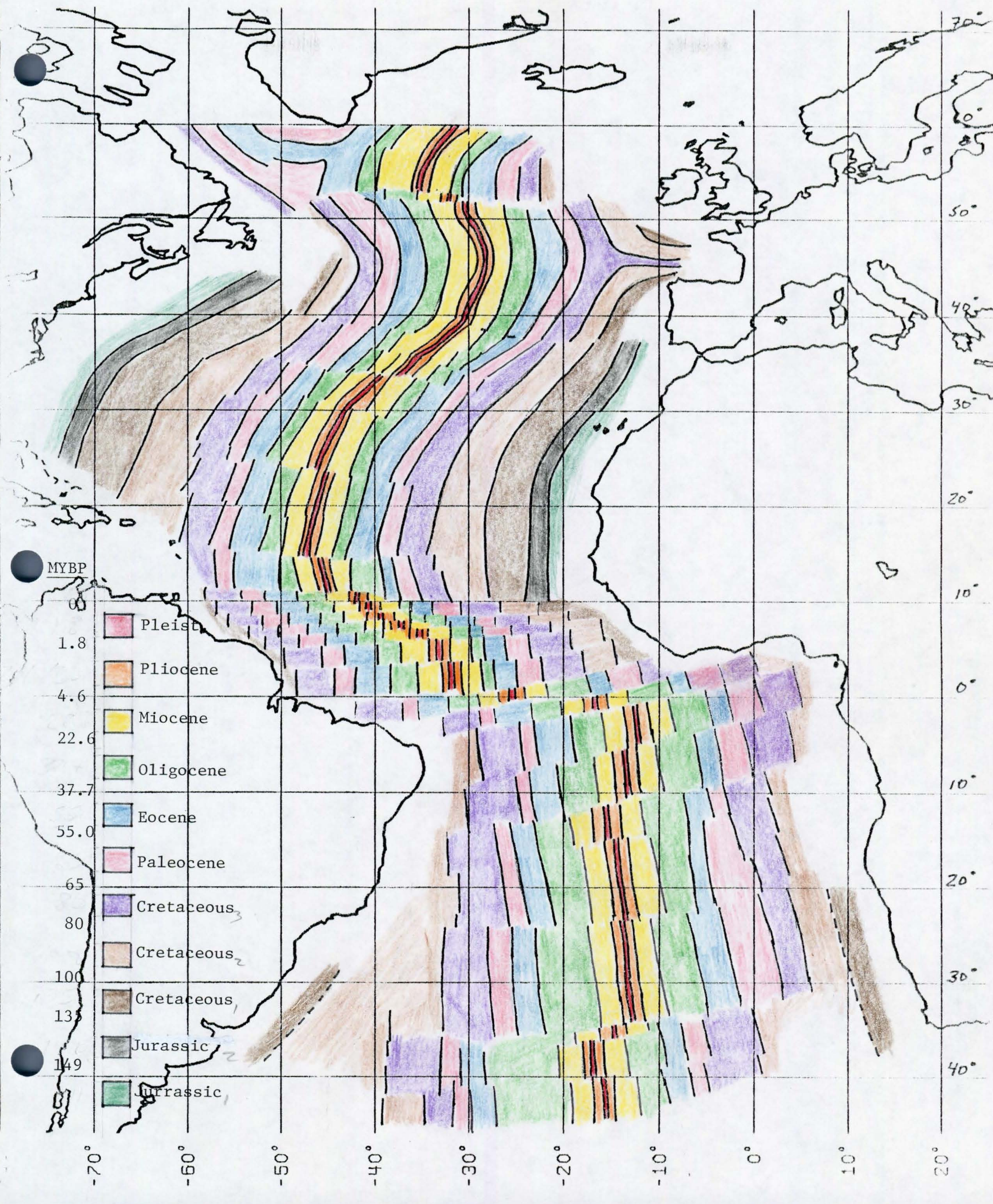


Plate 6. AGES of the ATLANTIC



Evolution of the North Atlantic

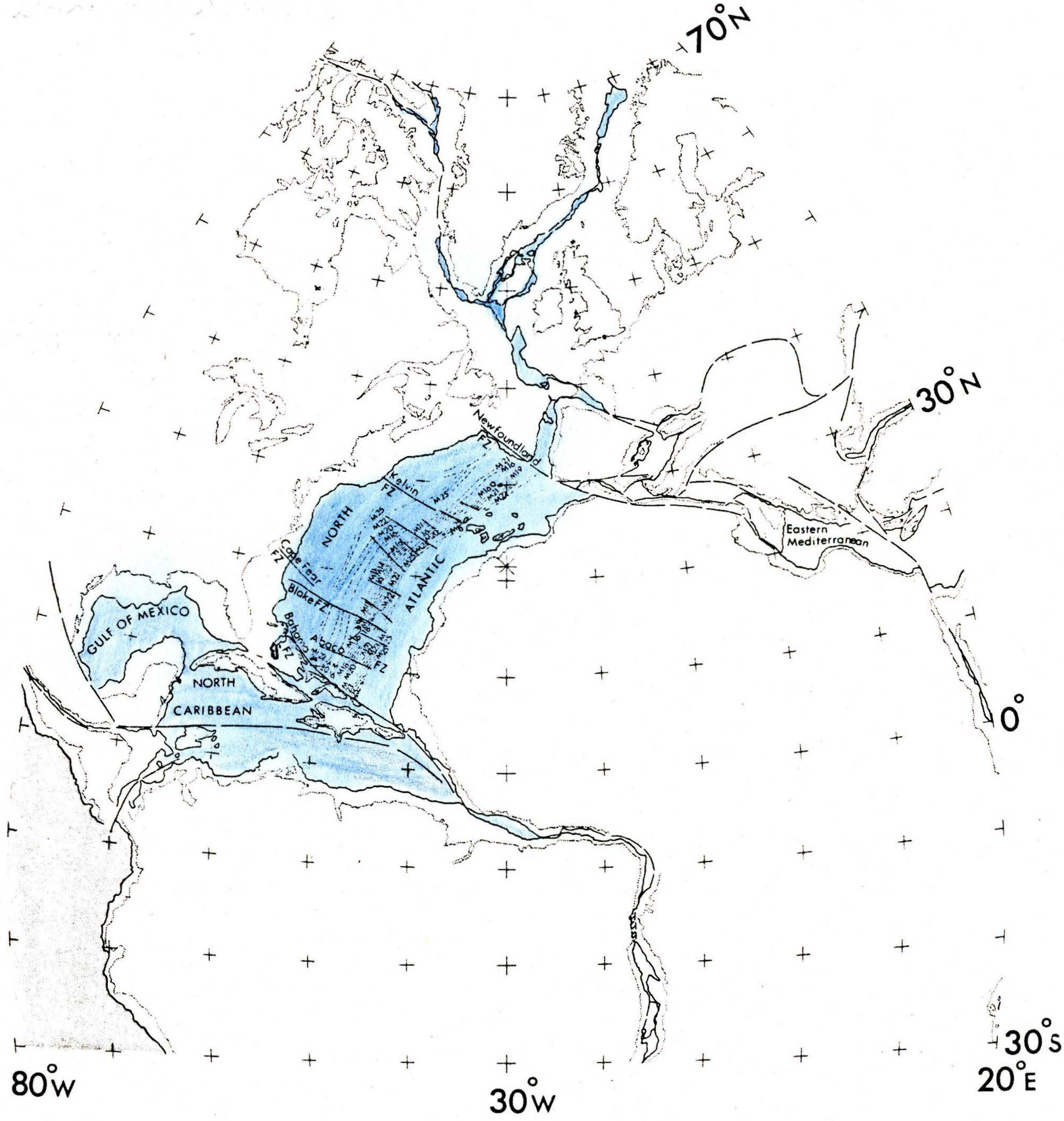
The following is a brief history of the evolution of the North Atlantic, as derived primarily from Owens (1981). It was compiled by the analysis and study of various geophysical sources already discussed, as well as by the study of the match between adjacent continental margins.

The opening of the Atlantic was preceded by major rift-faulting which extended back into the Triassic,possibly as early as 200 Ma BP. However, the active phase of drift is considered not to have begun until 180 Ma BP, and the oldest -agnetic anomaly present, which dates the initiation of sea floor spreading, is of an age of 150 Ma BP, which corresponds to the late middle Jurrassic.

Beginning with Pangea (180-200 Ma), the northwest margin of Africa was in contact with the east coast of North America, while Eurasia was in contact with America further to the north. With the advent of sea floor spreading the southern region of the North Atlantic began to widen, while the northern region remained closed.The resultant effects wre that during the Upper Jurassic, North America and Africa rotated away from each other while tension and continental splitting occured further north. This initiated differential motions between the northern region of Africa and the southern region of Europe, whuch then produced major wrenching motions between the continents, and led to the large scale fold belts seen today in the Mediterranean Region. During the Kimmeridgan of the Jurassic, this then started the counter clockwise rotation of the Iberian Penninsula, wkich subsequently produced the Bay of Biscay oceanic crust(map 1.).

During the late Jurrasic and early Cretaceous, the spreading center continued to extend northward between North America's Grand Bank continental shelf and the Iberian Peninsula until it formed a triple juntion point, which was essentially present due to the ptogressive widening of the southerly regions of the North Atlantic. This tension led to the offshoot of two northerly

Anomaly M7 (120 Ma) Hauterivian
ca 87% of modern diameter
Projection pole 22°N, 30°W



limbs from the triple junction: one to the northeast, and the other to the northwest. The northeast limb, the first to develop, ran through the North Sea, by the United Kingdom, and between Greenland and Norway re-activating older rift faults. This limb produced block faulting and rifting across southern England and northern France, approximately at the time of the Jurassic-Cretaceous boundary, or 135 Ma Bp.

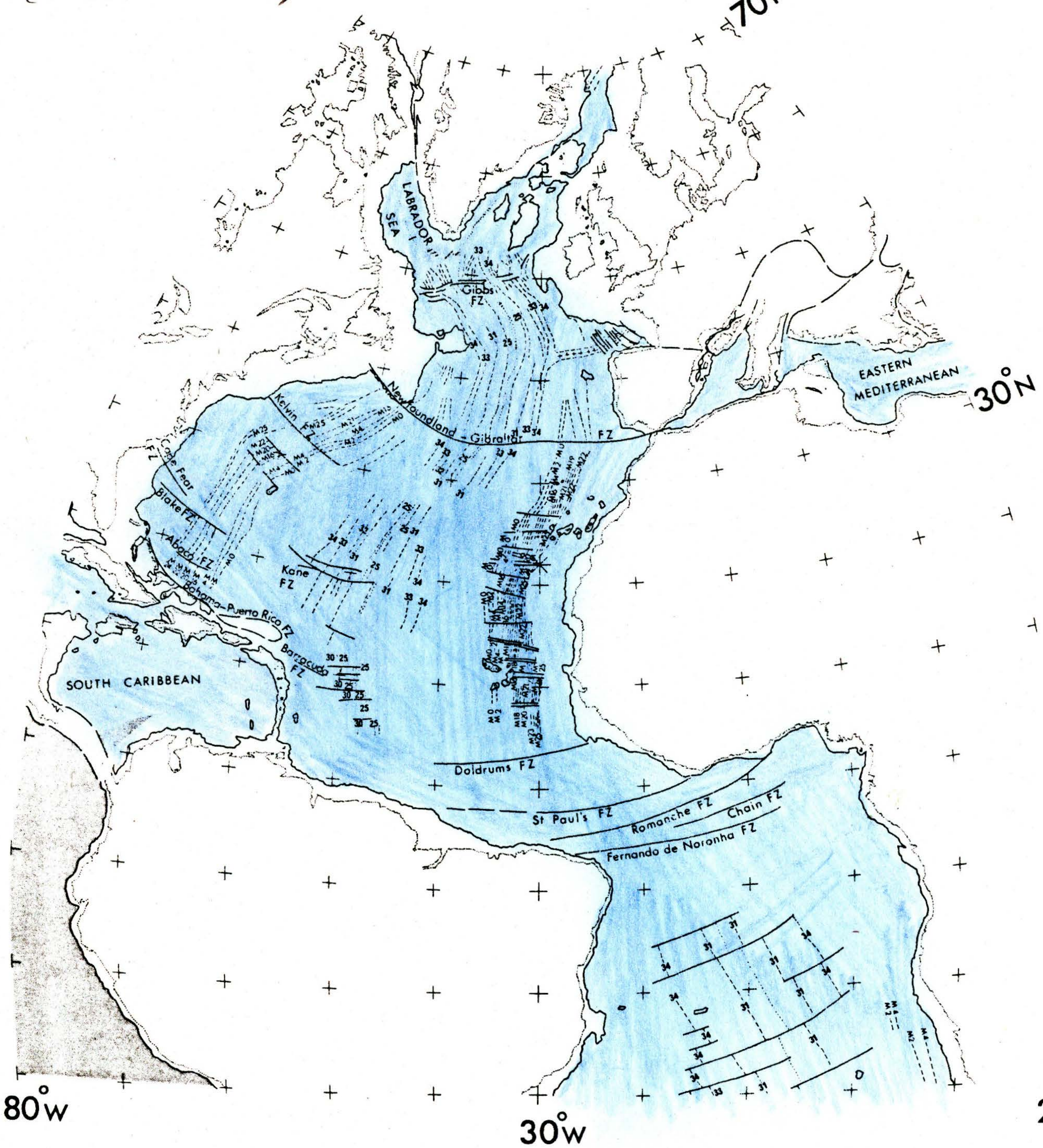
The northwest limb, during the Mid-Cretaceous, initiated the development of sea floor spreading in what is now the Labrador Sea, situated between the Canadian and Greenland continental margins. This spreading axis created the mid-Labrador Sea Ridge (Ran Ridge), and extended northward to form the Davis Strait and Baffin Bay (map). However, during the early Oligocene, it ceased crustal generation during anomaly 19 and became dormant.

Another speading axis developed along the former Mesozoic Rift Valley system that lay between Greenland and Scandinavia. After the northwest limb (from the triple junction) become dormant in the early Paleocene, this axis became the sole generating ridge in the North Altantic. This ridge generated the Denmark Strait and the Norwegian- Greenland Sea, and is known progressively

MAP 5

Anomaly 24 (56 Ma) Palaeocene
ca 94% of modern diameter
Projection pole 22°N, 30°W

(FROM OWEN, 1983



as the Reykjans- Iceland Ridge and the Mohns-Knipovich Ridge, and ultimately as the Nansen or Gakel Ridge in the Arctic.

From the Oligocene to present time, the continents essentially continued to "drift" in the manners already described. Owens provided a useful way to summarize the evolution of the North Atlantic with the following:

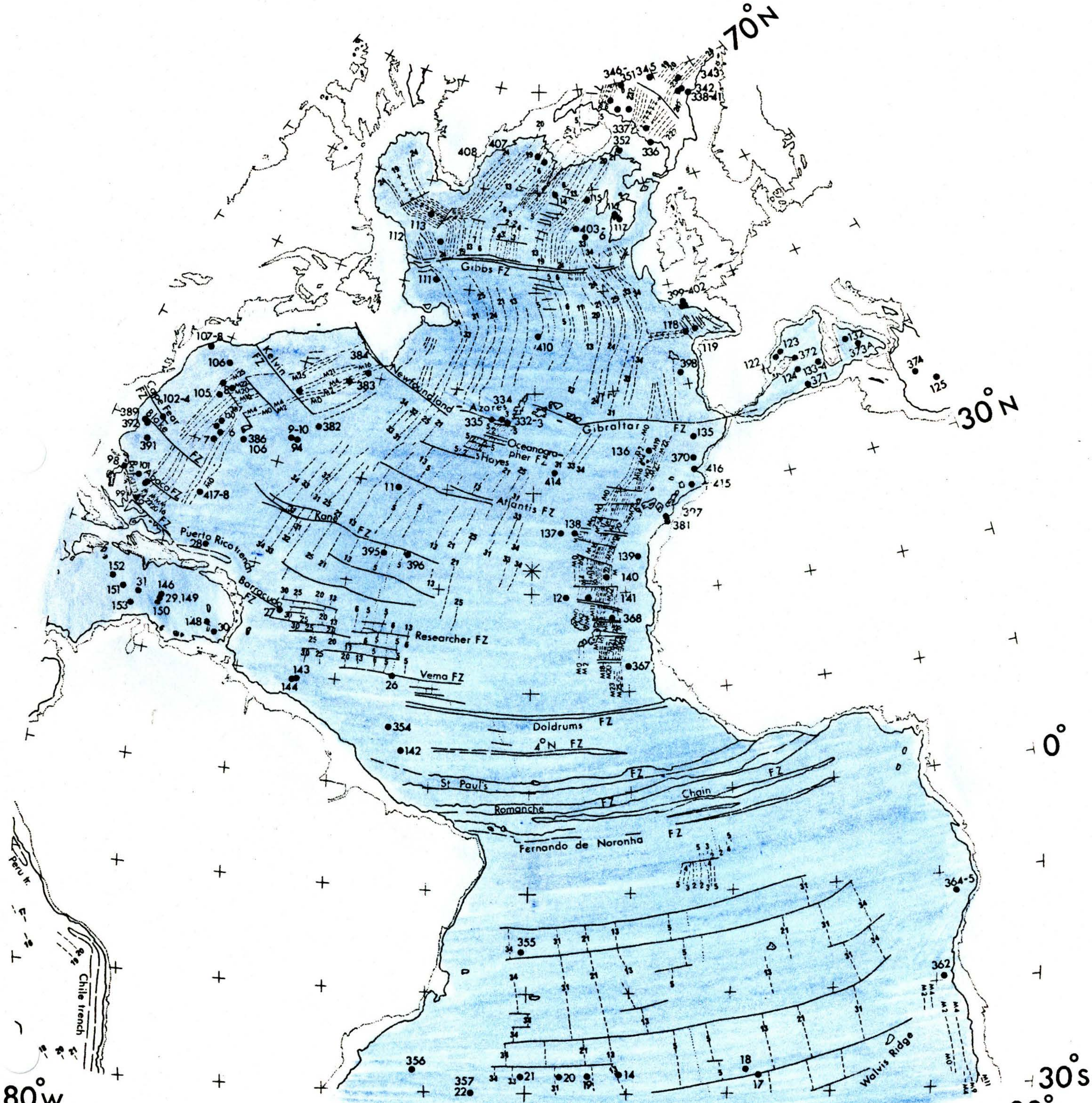
> The North Atlantic can be visualized as a spherical triangle, the early base of which is marked by the Bahama-Doldrums fracture zone. As the base widened, so the apex of the triangle extended northward separating North America from Africa, initially, and from the European- Greenland margin, subsequently. Continued widening to the south caused by the apex to extend firstly between Canada and Greenland, and then between Greenland and Europe, and into the Arctic.

With respect to the sea floor spreading rates, these have differed at all times during the opening of the North Atlantic. Although the major rifting was initiated in the Jurassic, the major phase of drift between North America and Eurasia did not occur until the late Cretaceous (Pitman and Talwani, 1972). From the late Cretaceous until 53 MaBP (which corresponds with anomaly 23 and the Eocene-Paleocene boundary), the spreading rate varied from 4.0-5.0 cm/yr., at 45^{o} N. latitude. Then the rate slowed down--from 53 M.4-9 M.4. ago (late Miocene-early Eocenic) with the average rate was just less than 2 cm/yr. At about

MAP 7

Modern
For sources see text
Projection pole 22°N, 30°W

(FROM OWEN, 1983)



anomaly 5, 9 M.Y. ago, there appears to be a discontinuity in the sediment on either side of the Mid-Atlantic Ridge, just north of the Azores. Finally, from this discontinuity to the ridge, or 9 M.Y. ago until present, the separation rate has been somewhat greater than 2.0 cm/yr. (Pitman & Talwani, 1972).

The average spreading rates between North America and Africa, as computed for a latitude of 35° N., are as follows:

"4.0 cm/yr. from 180 M.Y. to 81 M.Y. ago
3.4 cm/yr. from 81 M.Y. to 63 M.Y. ago
2.4 cm/yr. from 63 m.y. to 39 m.y. ago
2.0 cm/yr. from 38 m.y. to 9 m.y. ago
1.8 cm/yr. from 9 m.y. to the present."

Again, the rates slow until about 9 M.Y. ago, and then they begin to increase. To explain this behavior, Ewing and Ewing (1967) proposed that a global hiatus in spreading had occurred prior to anomaly 5 (9 M.Y. ago). They based this conclusion on the fact that sediment thicknesses appeared to increase anomalously at about anomaly 5 in many areas. However, Pitman and Talwani argue that because ". . . (there is) no apparent slowing or cessation in spreading north of the Azores means that the sediment discontinuity so apparent in this region must be due to other causes."

Evolution of the South Atlantic

The early history of the South Atlantic shows that, although it is now a continuous spreading zone with the North Atlantic, these two oceans developed quite separately until the Mid-Cretaceous. Major rift-faulting occurred between South America and Southern Africa during the Jurassic, but it was not until the early Cretaceous (Valinginian) that sea floor spreading began. Again, as in the case of the North Atlantic, the base of the developing triangle was situated in the south as marked by the Agulhas and Falkland fracture zones. The apex extended rapidly northward during the lower Cretaceous, and by the late lower Cretaceous had formed a triple junction between the Northeast Brazilian/Nigerian continental margin. Again, two limbs formed from this triple junction; one to the northeast, and one to the northwest. The northeast limb formed the oceanic floor of te Benue Trough, which was overlain by Albian sediments. The Northwest limb of the triple junction extended between the African/Guinea Coast and the North Brazilian continental margins.

The remaining history of the sea floor speading in the South Atlantic is simply that of continued widening of the basin with South America undergoing a clockwise rotation in response to the greater area of oceanic crust generated in the south, as compared to that in the north. (However, this is not the case for the region south of the Falkland-Agulhas fracture zone, which is closely linked with the development of the western part of the Indian Ocean. This region will not be discussed due to its complexity and due to the fact that it is located outside the mappable boundaries of the plates. The joining of the ridges of the North and South Atlantic occurred during the Turonian (Cretaceous) which resulted in the common mid Atlantic Ridge now present today.

CONCLUSION

The correlation between the geophysical characteristics of the Atlantic Ocean seems to be of a quite limited nature. However, certain relationships do exist. First, the presence of the many sea floor features such as seamounts aseismic ridges are undoubtedly due to the presence of hotspots and their tracks. Second, the trends of these hotspot tracks in the South Atlantic bear a remarkable resemblence to the trends of the magnetic anomalies also found there. Von Frese, et al (1984) believe this may be due to the "Magnetic Signature Imprint" left at these hotspots, but no definite conclusions have been reached. Third, there seems to be no extremes in the gravity anomalies, either positive or negative associates with the location of known hotspots.

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